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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/649,351	08/26/2003	Sang-Hyeob Lee	NOVLP033X1/NVLS-000498X1	4174

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EXAMINER	
NGUYEN, HA T	
ART UNIT	PAPER NUMBER
2812	

DATE MAILED: 12/30/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/649,351	LEE ET AL.	
	Examiner	Art Unit	
	Ha T. Nguyen	2812	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *17 October 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-13,15-29 and 32-35* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-13,15-29 and 32-35* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *10-17&12-8-5*.
4) ☒ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

1. Applicants' Amendment and Response to the Office Action mailed 7-14-5 and Request for a Continued Examination have been entered and made of record. Following is an Office Action responding to the request.

Claim Rejections - 35 USC § 112

2. Claim 15 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 15 depends from cancelled claim 14.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103□ and potential 35 U.S.C. 102(f) or (g) prior art under 35 U.S.C. 103(a).

4. Claims 1-13, 15, 19-29, and 32-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee et al. (USPN 5956609, hereinafter "Lee") in view of Klaus et al.' s

"Atomically controlled growth of tungsten and tungsten nitride using sequential surface reactions" (hereinafter "Klaus") or Fang et al. (USPAPN 20030104126).

Referring to the Figs 2A-4D and related text, Lee discloses [Re claims 9-10, 13, and 15] a method of forming a tungsten nucleation layer on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer 30 on the semiconductor substrate 20 by contacting the semiconductor substrate with tungsten-containing gas and a reducing agent in the presence of nitrogen; and (b) depositing a tungsten bulk layer 32, 34 on the tungsten nucleation layer by a CVD process in which the semiconductor substrate is exposed to nitrogen; wherein (b) comprises exposing the semiconductor substrate to a tungsten-containing gas selected from the group consisting of WF6 and W(CO)6 and combinations thereof (See col. 4, line 43-col. 6, line 54). But it fails to disclose expressly the use of alternating pulses of reactant gases; wherein (a) composes performing PNL by alternating exposure of the semiconductor substrate to the tungsten-containing gas and the reducing agent; wherein (a) comprises delaying exposure of the semiconductor substrate to nitrogen until after deposition of the tungsten nucleation layer has begun. However, the missing limitations are well known in the art because Klaus discloses these features (See pages 480 left col., 482, and 485, right col.), the examiner interpreted that the substrate is exposed to N2 is delayed because the deposition of the tungsten nucleation has begun with the first exposure to WF6 in the first cycle or Fang discloses these features (see Fig. 1, Summary, and par. 27), when exposure cycle is short the delay would be in matter of a second. A person of ordinary skill is motivated to modify Lee with Klaus or Fang to obtain good step coverage, smooth W layer with low impurity (see Klauss, Abstract).

[Re claims 11-12] Lee also discloses wherein the nitrogen employed in (a) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate and wherein the nitrogen employed in (b) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate (see col. 4, lines 49- col. 5, line 25). Note that in the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a prima facie case of obviousness exists. In re Wertheim, 541 F. 2d 257, 191 USPQ 90 (CCPA 1976); In re Woodruff, 919 F. 2d 1575, 16 USPQ 2d 1934 (Fed. Cir. 1990).

[Re claim 1] The combined teaching of Lee and Klaus or Fang discloses a method of forming a tungsten film on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer 30 on the semiconductor substrate 20; (b) depositing a tungsten bulk layer 32 on the nucleation

layer using a chemical vapor deposition (CVD) process, as shown above. Lee also discloses (c) depositing a tungsten cap layer 34 on the tungsten bulk layer 32. In the combined teaching of Lee and Klaus or Fang, a pulsed nucleation layer (PNL) deposition technique is used; note that the ALD method of Klaus or Fang is a special CVD method. In Lee, the high pressure used in the formation of the third layer allows for a high reflectivity, therefore smooth or less rough tungsten layer (see col. 5, lines 19-25).

[Re claims 2-8] Fang discloses repeating (b) and (c) multiple times; wherein (a) comprises: positioning the semiconductor substrate in a reaction chamber; heating the semiconductor substrate; and performing PNL on the semiconductor substrate using a tungsten-containing gas and a reducing gas; wherein the reducing agent is a silane; wherein (b) comprises exposing the semiconductor substrate to a process gas comprising one or more of the following: WF6-H2, WF6-B2H6, and W(CO)6; wherein the PNL comprises: (i) flowing a reducing gas into a deposition chamber holding the semiconductor substrate, whereby the reducing gas is adsorbed onto said semiconductor substrate; (ii) purging the reducing gas from the deposition chamber; (iii) flowing a tungsten-containing gas into said deposition chamber, whereby said deposited reducing gas is substantially reduced to a tungsten film; (iv) purging the tungsten-containing gas from the deposition chamber; and (v) repeating (i) through (iv) for one or more additional cycles; wherein the reducing gas is a silane (see Fig. 1 and pars. 23-28) or Klaus discloses these features (see pages 479-480 and par. bridging the two columns in page 482).

[Re claims 19-29 and 32] The combined teaching of Lee and Fang or Klaus discloses a method of forming a tungsten film on a semiconductor substrate in a reaction chamber, the method comprising: (a) forming a reducing layer on the semiconductor substrate; (b) contacting the reducing layer with a tungsten-containing gas to thereby reduce the tungsten-containing gas to a tungsten layer on the semiconductor substrate; (c) contacting the semiconductor substrate with silane to form a layer of silane; and (d) contacting the layer of silane with the tungsten-containing gas to thereby reduce the tungsten-containing gas to another tungsten layer on the semiconductor substrate, as shown above. Fang also disclose the reducing layer to be a boron layer and reducing gas being diborane, decomposed at about 350C ; heating the semiconductor substrate to a temperature of between about 200 and 400C and contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the vapor phase comprises a nitrogen carrier gas in addition to the borane compound; purging the reaction chamber of the borane compound after contacting the semiconductor substrate with the borane

compound in the vapor phase; wherein the semiconductor substrate is contact with the borane compound for a period of between about 0.1 and 10 seconds; wherein the tungsten-containing gas of (b) and (d) has the same composition; wherein the tungsten-containing gas of (b) comprises WF6; wherein the layer of reducing agent formed in (c) is a self- limiting layer; repeating (c) and (d) for at least one cycle (see Fig. 1 , pars. 20, 24, and 28).

[Re claims 33-35] The combined teaching of Lee and Fang or Klaus discloses substantially the limitations of claims 33-35, as shown above. But it fails to disclose expressly exposing the semiconductor substrate to a pulse of WF6 prior to (a) and the details about the claimed duration of the tungsten-containing gas exposure; and wherein the duration of contacting with the tungsten- containing gas in (b) is shorter than the duration of contacting with the tungsten-containing gas in (d). However, However, it is well known in the art that any order of applying reactants in a cyclic deposition method is acceptable. It would have been obvious to an ordinary artisan to do so to obtain an appropriate amount of reactants for each cycle and to prevent corrosion of underlying layer from HF, a reaction by-product and the shorter duration of exposure of WF6 in earlier cycle is preferable to reduce attack from HF by-product.

Therefore, it would have been obvious to combine Lee with Klaus or Fang to obtain the invention as specified in claims 1-13, 15, 19-29, and 32-35.

5. Claims 1-13, 15, and 19-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang et al. (USPN 5028565, hereinafter "Chang") in view of Klaus.

Referring to the Fig. and related text, Chang discloses [Re claims 9-10, 13, and 15] a method of forming a tungsten nucleation layer on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate by contacting the semiconductor substrate with tungsten-containing gas and a reducing agent in the presence of nitrogen; and (b) depositing a tungsten bulk layer on the tungsten nucleation layer by a CVD process in which the semiconductor substrate is exposed to nitrogen; wherein (b) comprises exposing the semiconductor substrate to a tungsten-containing gas selected from the group consisting of WF6 and W(CO)6 and combinations thereof (See col. 4, line 49-col. 5, line 68). But it fails to disclose expressly the use of alternating pulses of reactant gases; wherein (a) composes performing PNL by alternating exposure of the semiconductor substrate to the

tungsten-containing gas and the reducing agent; wherein (a) comprises delaying exposure of the semiconductor substrate to nitrogen until after deposition of the tungsten nucleation layer has begun. However, the missing limitations are well known in the art because Klaus discloses these features (See pages 480 left col., 482, and 485, right col.), the examiner interpreted that the substrate is exposed to N2 is delayed because the deposition of the tungsten nucleation has begun with the first exposure to WF6 in the first cycle and when exposure cycle is short the delay would be in matter of a second. A person of ordinary skills is motivated to modify Chang with Klaus to obtain smooth nucleation layer with low impurity (see Abstract).

[Re claims 11-12] Chang also discloses wherein the nitrogen employed in (a) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate and wherein the nitrogen employed in (b) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate (see col. 5, lines 8-19).

[Re claims 19-24, 26-27, 29, 32 and 35] The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate in a reaction chamber, the method comprising: (a) forming a reducing layer on the semiconductor substrate; (b) contacting the reducing layer with a tungsten-containing gas to thereby reduce the tungsten-containing gas to a tungsten layer on the semiconductor substrate; (c) contacting the semiconductor substrate with a reducing agent to form a layer of reducing agent; and (d) contacting the layer of reducing agent with the tungsten-containing gas to thereby reduce the tungsten-containing gas to another tungsten layer on the semiconductor substrate; heating the semiconductor substrate to a temperature of between about 200 and 400C and contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the vapor phase comprises a nitrogen carrier gas in addition to the borane compound; purging the reaction chamber of the borane compound after contacting the semiconductor substrate with the borane compound in the vapor phase; wherein the tungsten-containing gas of (b) and (d) has the same composition; wherein the tungsten-containing gas of (b) comprises WF6; wherein the layer of silane formed in (c) is a self- limiting layer; repeating (c) and (d) for at least one cycle; exposing the semiconductor substrate to a pulse of WF6 prior to (a), as shown above. But it does not disclose that the reducing agent is a borane compound, diborane. However, the examiner takes Official Notice that it is well known in the art that diborane and silane are equivalently used as reducing agent. It would have been obvious to use one of diborane and silane in the whole process or diborane in some cycles and silane in other cycles

depending on the requirement of a specific application or the availability of either gas in other process step. When diborane and silane are successively used in the deposition process, the claims limitations are met.

[Re claims 25, 28, and 33-34] The combined teaching of Klaus and Chang does not disclose expressly the claimed duration of exposure to reactants and wherein the duration of contacting with the tungsten- containing gas in an earlier cycle is shorter than the duration of contacting with the tungsten-containing gas in a later cycle; and wherein the duration of contacting with the tungsten- containing gas in (b) is shorter than the duration of contacting with the tungsten-containing gas in (d). However, it would have been obvious to an ordinary artisan to do so to obtain an appropriate amount of reactants for each cycle and to prevent corrosion of underlying layer from HF, a reaction by-product.

[Re claims 1-8] The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate; (b) depositing a tungsten bulk layer on the nucleation layer using a chemical vapor deposition (CVD) process; wherein (a) comprises: positioning the semiconductor substrate in a reaction chamber; heating the semiconductor substrate; and performing PNL on the semiconductor substrate using a tungsten-containing gas and a reducing gas; wherein the reducing agent is a silane; wherein (b) comprises exposing the semiconductor substrate to a process gas comprising one or more of the following: WF6-H2, WF6-B2H6, and W(CO)6; wherein the PNL comprises: (i) flowing a reducing gas into a deposition chamber holding the semiconductor substrate, whereby the reducing gas is adsorbed onto said semiconductor substrate; (ii) purging the reducing gas from the deposition chamber; (iii) flowing a tungsten-containing gas into said deposition chamber, whereby said deposited reducing gas is substantially reduced to a tungsten film; (iv) purging the tungsten-containing gas from the deposition chamber; and (v) repeating (i) through (iv) for one or more additional cycles; wherein the reducing gas is a silane, as shown above. When considering each deposited W layer for each cycle in the formation of a bulk layer to be alternated bulk and cap layers, the claimed limitations, (c) depositing a tungsten cap layer on the tungsten bulk layer using a pulsed nucleation layer (PNL) deposition technique; and repeating (b) and (c) many times, are met.

Therefore, it would have been obvious to combine Chang with Klaus to obtain the invention as specified in claims 1-13, 15, and 19-35.

6. Claims 16-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee with Klaus or Fang; or Chang in view of Klaus, as applied above, and further in view of Berenbaum et al. (USPN 6066366, hereinafter "Berenbaum").

The combined teaching of Lee and Klaus or Fang; or Chang and Klaus discloses substantially the limitations of claims 16-18, as shown above.

But it fails to disclose expressly the claimed timing of the introduction of nitrogen.

However, the missing limitations are well known in the art because Berenbaum discloses these features (See Fig. 1, experiments 2 and 3).

A person of ordinary skill is motivated to modify Lee and Klaus or Fang; or Chang and Klaus with Berenbaum to obtain stable deposition of W compound.

Therefore, it would have been obvious to combine Lee and Klaus or Fang; or Chang and Klaus with Berenbaum to obtain the invention as specified in claims 16-18.

Response to Amendment

7. In view of Applicants' arguments and the amendment to the claims, the rejection of claims 1-8 under 35 U.S.C. 103 (a), as being unpatentable over the combination of Chang, Klaus, and Sukharev; and of claim 15 over the combination of Chang, Klaus, and Berenbaum, as stated in the above indicated Office Action, has been withdrawn.

Applicants' arguments with regard to the other rejections under 35 U.S.C. 103 have been fully considered, but they are not deemed to be persuasive for at least the following reasons.

Applicants argued that none of the applied references disclose the use of two different reducing agents. The examiner asserts that because the two reducing agents are well known to be equivalent, the use of one of the two or both at different steps is not a matter of novelty but rather of convenience or design for a specific application to meet the desired processing flow.

Applicants also argued that none of the applied references disclose the decomposition of borane on the substrate. However, it is inherent that borane decompose when it is in contact with a substrate heated at high temperature, as in the case taught by the combined teaching.

Applicants argued that Berenbaum teaches away from the claimed invention. The examiner disagreed. Even though Berenbaum discloses instability at some deposition condition,

in the conditions used in the rejection, the teaching of Berenbaum is positive for the combined teaching.

Therefore, the applied references do teach or make obvious all the limitations of the rejected claims 1-13, 15-29, and 32-35.

Conclusion

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ha T. Nguyen whose telephone number is (571) 272-1678. The examiner can normally be reached on Monday-Friday from 8:30AM to 6:00PM, except the first Friday of each bi-week. The telephone number for Wednesday is (703) 560-0528.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael S. Lebentritt, can be reached on (571) 272-1873. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

HN

12- 26 -05

Ha Nguyen

Primary Examiner